

## The NOAA National Status and Trends Program

Beach closures, shellfishing bans, health warnings to fisherman, waste discharges to the sea, ocean dumping, losses of wetland, accidental spills of oil and hazardous chemicals, marine mammal strandings, trash washing ashore, fish kills, blooms of harmful algae, and summertime oxygen depletions all arouse public concern over the quality of the marine environment. To assess the effects of human activities on the quality of coastal and estuarine areas throughout the United States, the National Oceanic and Atmospheric Administration (NOAA) created the National Status and Trends (NS&T) Program in 1984. While not every untoward event in the marine environment is attributable to chemical contamination, NS&T has, to date, focused on monitoring trends of chemical contamination in space and time and to determine biological responses to that contamination. The primary goals are to quantify the extent to which chemical contamination is causing environmental harm and to determine whether contamination is decreasing or increasing.

The need for this type of wide-scale monitoring was emphasized by U.S. National Research Council. Their report "Managing Troubled Waters" (NRC, 1990) indicated that the United States annually spends more than \$130 million dollars on marine environmental monitoring but that most of it is devoted to compliance monitoring; i.e., testing wastewaters and other materials prior to discharge or to performing measurements prescribed by regulation very near discharge points. Since compliance monitoring, by design, covers very small spatial scales, it is programs such as NS&T that are required to focus on wider public concerns. This has been done through collection and chemical analyses of mollusks, sediment, and fish from sites around the nation, through analysis of fish for response to chemical contamination, and assays of sediment toxicity.

From 1965 to 1972, Butler (1973) inaugurated wide-scale monitoring through analyses of fish and mollusks collected throughout the coastal and estuarine United States (Lauenstein and Daskalakis, this issue). The main concern of that program was possible contamination of commercially harvested mollusks with the chlorinated pesticides commonly used in those years. The Goldberg *et al.* (1978) nationwide project of 1976 to 1978 introduced the term "Mussel Watch" for a program using mollusks as sentinel organisms to monitoring chemical contamination. Mollusks serve that purpose because they concentrate chemicals from their surroundings making the chemical analyses simpler and less prone to error than that for water, they stay in a single location rather than swim around, and that are fairly resistant to chemical contamination and could be found living in areas where less hardy species may be absent. The NS&T program has a Mussel Watch component that follows those earlier programs in its annual sampling of indigenous mollusks. The intent has been to monitor the spatial extent and temporal changes in coastal contamination. O'Connor (this issue) reports on temporal trends through 1996 of trace elements and organic chemicals monitored since at least 1990, Wade *et al.* (this issue) discuss the distribution of chemicals only recently added to the program, Lehotay *et al.* (this issue) examine which presently used pesticides are and are not accumulated by

oysters, and Gardinali and Wade (this issue) compare the contributions of polycyclic aromatic hydrocarbons, planar PCBs, chlorinated dioxins, and chlorinated dibenzofurans to Total Induction Factors in mollusk tissues.

Periodic sampling of mollusks is a strategy for monitoring temporal trends in chemical concentrations. However, because a single species is not available nationwide, comparisons among sites for spatial trends is somewhat compromised. Differences in chemical concentrations can be due to different molluscan species as well as to different levels of environmental contamination. Nonetheless, concentrations of organic chemicals have shown no species effect at NS&T sites (O'Connor and Ehler, 1990). Several species of mollusks have been used in the International Mussel Watch Program (Sericano *et al.* 1995) for monitoring spatial differences in concentrations of organic chemicals.

Sediments, on the other hand, provide a basis for spatial comparisons of both organic chemical and trace element concentrations. The NS&T Program has collected and analyzed sediments from all of its sampling sites (e.g. Meador *et al.*, this issue). Sediments are often collected in local and regional studies and this allows the NS&T results to be put into a larger context. For example, Cantillo and O'Connor (1992) compared the distributions of concentrations in sediments analyzed by NS&T with distributions in a worldwide dataset extracted from over 200 publications. Daskalakis and O'Connor (1995) used electronically stored data to compile a 13,000 sample dataset for U.S. coastal areas and, thereby, greatly extending the NS&T data.

Mollusks can adjust their concentrations of chemicals in response to changes in their environment and, in fact, this characteristic is exploited in regional or local programs that deploy caged mollusks to monitor chemical concentrations in areas of particular interest. Sediments, on the other hand, are not so responsive and periodic collections of surface sediment, unless one knew the time over which that sediment had accumulated, are not amenable to trend analysis. Long term trends with 5-10 year resolution over 100 or more years can, however, be extracted from sediment cores. Valette-Silver (1993) has explained how this technique is being applied by the NS&T program at several locations around the coastal US.

The NS&T Benthic Surveillance Program was similar to the Mussel Watch Program except that fewer sites were sampled, livers and stomach contents of bottom fish were analyzed rather than whole soft parts of mollusks, and there was a strong emphasis on examining fish for biochemical, histopathological, or reproductive changes that could be attributed to exposure to chemical contamination. The antecedent to Benthic Surveillance was the Northeast Monitoring Program, itself based on the Ocean Pulse Program, of the NOAA Northeast Fisheries Center (NOAA, 1981). Here, as with Benthic Surveillance, wide-scale monitoring of chemical concentrations and myriad biological parameters was done to determine the extent of human influence on the coastal environment. Brown *et al.* (this issue) examine relationships between chemical concentrations in sediment, stomach content and fish livers at Benthic

Surveillance sites on the U. S. West Coast. As is the case with mollusks (O'Connor and Ehler, 1990) there is a strong association between concentrations in sediments and tissues for organic contaminants but not for most trace elements. Using Benthic Surveillance data for sites on the Atlantic and Gulf of Mexico Coasts, Hanson (1997) found that, in areas where sediment contamination was high, concentrations of organic contaminants in fish livers tended to depress levels of zinc and, possibly, cadmium.

Within the Mussel watch Project, specimens have been examined for associations between biological responses and contamination. Kim *et al.* (this issue) has sought associations between chemical concentrations in mollusks and the presence and intensity of parasitic infections. Hillman *et al.* (1992) sought differences in body burdens of chemicals between 18 sites where neoplasia was observed in at least one individual mussel (*Mytilus edulis*) and 49 sites where neoplasia was not observed in that species. However, the emphasis on biological effects has been with through examination of fish collected in the Benthic Surveillance Project and through sediment bioassays in the Bioeffects Project. The latter project does not involve nationwide monitoring but, rather, intensive surveys in individual estuaries. Results of bioassays have been summarized by Long *et al.* (1996) for surveys in 22 bays. However, evidence for in-situ associations of chemical contamination with biological change has been primarily sought through collection and analysis of fish. Collier *et al.* (this issue) discuss the distribution of and quantify correlations among three biochemical markers of responses to xenobiotic organic chemicals. Myers *et al.* (this issue) summarize a wealth of information on associations between liver lesions and chemical concentrations in sediment, stomach content, livers.

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Guest editor

Editors note: The editor and the authors of two papers in this collection, Collier *et al.* and Brown *et al.*, disagree on the number of observations ("n") from which Spearman rank correlation coefficients and their significance are computed to identify temporal trends. The editor believes that in a correlation of concentration (Brown *et al.*) or enzymatic activity (Collier *et al.*) with year, the "n" is the number of years. The respective authors set "n" as the number of independent data points, a much larger number because several measurements were made in each year. The editor argues that the annual replicates should be reduced to a single number (a mean, or median, or geomean, or some other choice) to pair with the year.

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Goldberg (1992) has argued that environmental contamination by trace elements is not a serious problem. Nonetheless, metal concentrations keep being measured in all sorts of media and results consume many pages of environmental journals because the measurements are easy and bureaucrats insist that they still be made. He was particularly critical of "large scale monitoring programmes that continue [measuring metals] year after year without contributing to improvements in ocean quality or to marine science." In effect, a lot of time and money is being wasted on irrelevant environmental measurements. However, if that is true, the real waste is not unnecessary measurement but unneeded controls on discharges of metals.

As of January 1994 there were 82,954 industrial, municipal, and other facilities in the United States with permits to discharge into surface waters. The vast bulk of them do not have trace element limitations in their permit but 6614 do—only 8% of the total but still a large number. Even if each facility spent only \$1000 per year on paperwork or on actually controlling discharges, more than \$6 million would be devoted to the issue.

They are listed in the PCS files of National Pollution Discharge Inventory System (NPDIS) permittees. It has been argued that water contamination by trace elements is not a serious problem.

The case is simply based on the observation that few environmental problems are attributable to elemental contamination. This contrasts with avian reproductive problems caused by DDT (Riseborough.....), mammalian reproductive damage from PCBs, liver tumors in fish due to polycyclic aromatic hydrocarbons (Bauman, Varanasi.....)

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